NOKIA

25G/50G/100G EPON wavelength plan C

Ed Harstead, member Fixed Networks CTO
Dora van Veen, Vincent Houtsma, Bell Labs

Supporters:

John Johnson, Broadcom

Sept. 2016

Straw Poll # 1

The 802.3ca standard shall specify wavelengths for 25G, 50G, and 100G systems in O-Band.

Yes:	15
No:	0
Not enough information:	9

Those voting "Not enough information" in Straw Poll #1 suggested the following information is needed to make a decision.

1) Exact (detailed) wavelength plan including support for coexistence (TDM or WDM).
2) Full cost comparison between all O-Band and other solutions.
3) More consensuses in presentations.
4) Dispersion compensation analysis of all solutions.
5) Full power budget for full 100G system (including mux losses) and what is needed to close the gap.

Only 25G in O-band: Plan C

Wavelength Plan Inventory as of 7/27/16

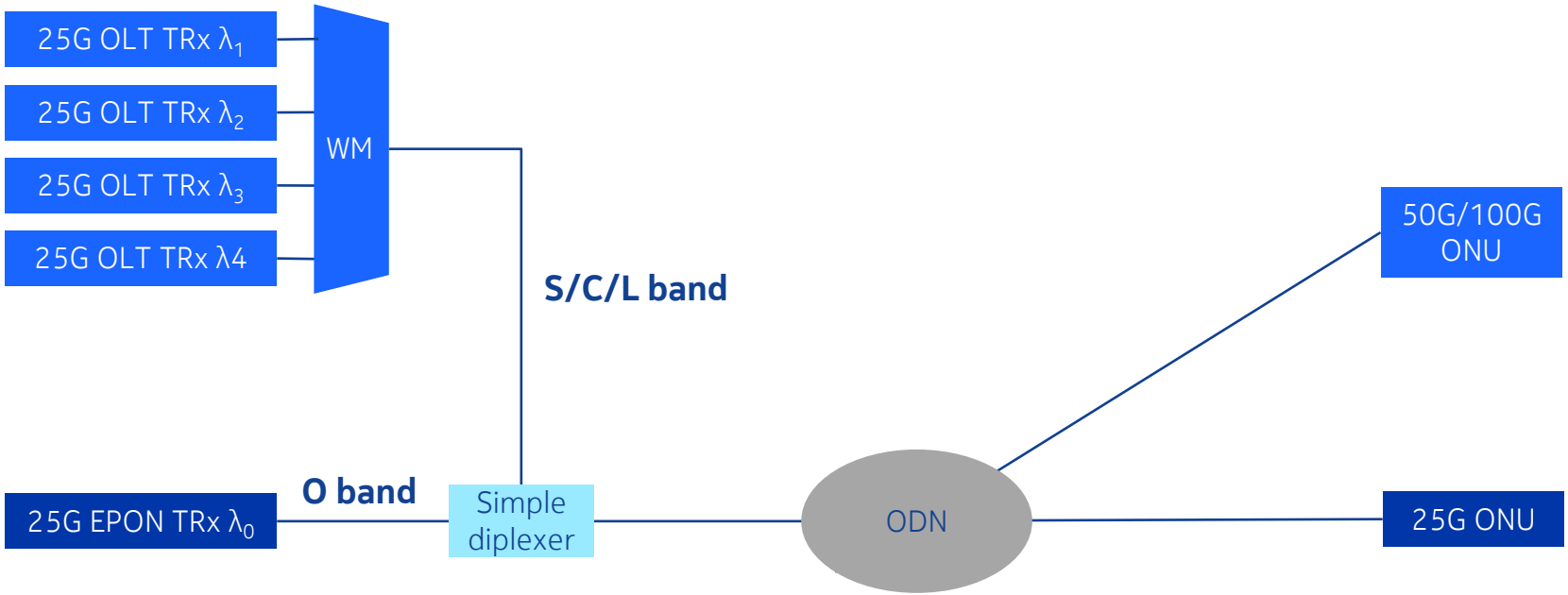
	A	B	C	D	E	F	G
ds0	O	O	O	S/C/L	O	O	
ds1	O	O	S/C/L	S/C/L	S/C/L	L	
ds2	O	O	S/C/L	S/C/L	S/C/L	L	
ds3	O	O	S/C/L	S/C/L	S/C/L	L	
ds4	none	O or none	S/C/L or none	none	none	L	
us0	O	O	O	O	O	O	
us1	O	O	S/C/L	O	O	C	
us2	O	O	S/C/L	O	O	C	
us3	O	O	S/C/L	O	O	C	
us4	none	O or none	S/C/L or none	none	none	C	
author	JJ+FE+YG #1	EH #1	EH#2	JJ	DL	ED	

kramer_3ca_5_0716.pdf

NOKIA

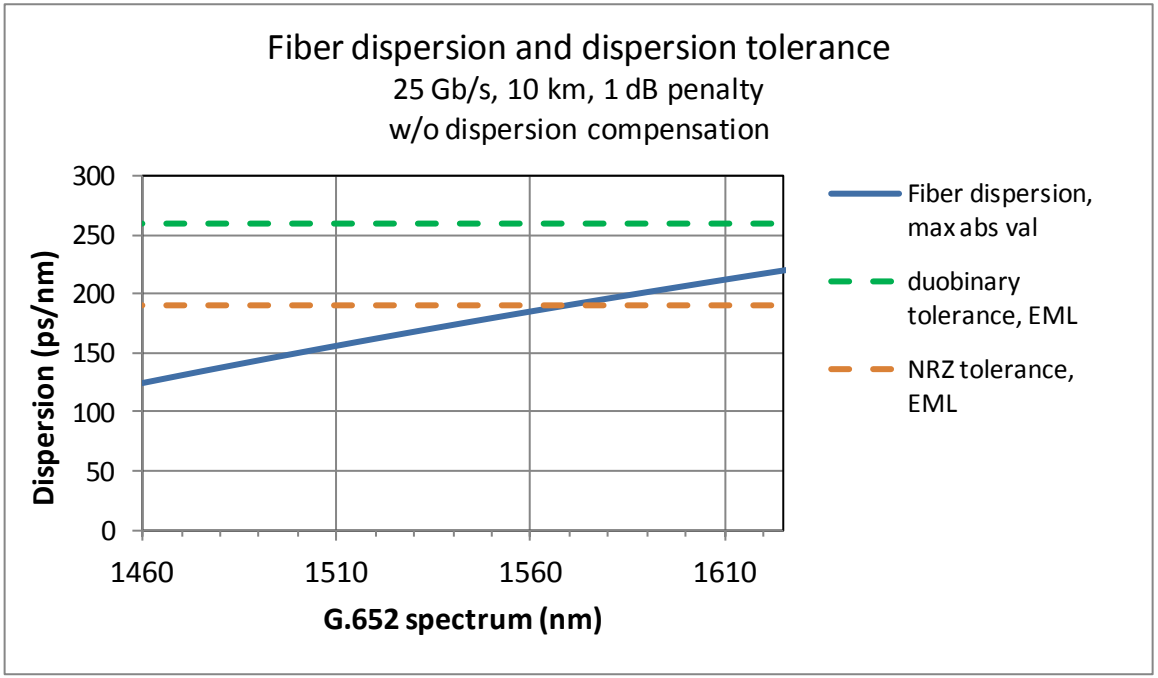
Plan C: high level optical architecture.
Focus on 1+4

Step 1: what wavelengths in the S/C/L band for λ_1, λ_2, λ_3, λ_4?
Step 2: what wavelengths in the O-band for λ_0?



NOKIA

λ_1 - λ_4 in the S/C/L band: dispersion tolerance



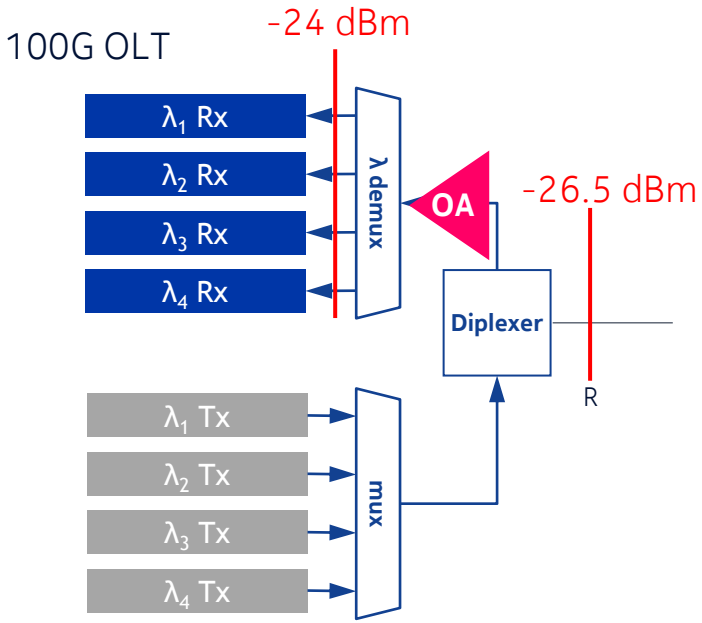
- 25G dispersion tolerance values based on simulations.
- Experimental data is welcome.

Must design for worst case: NRZ detection

No dispersion compensation required for NRZ detection up to 10 km for wavelengths up to ~1560 nm

NOKIA

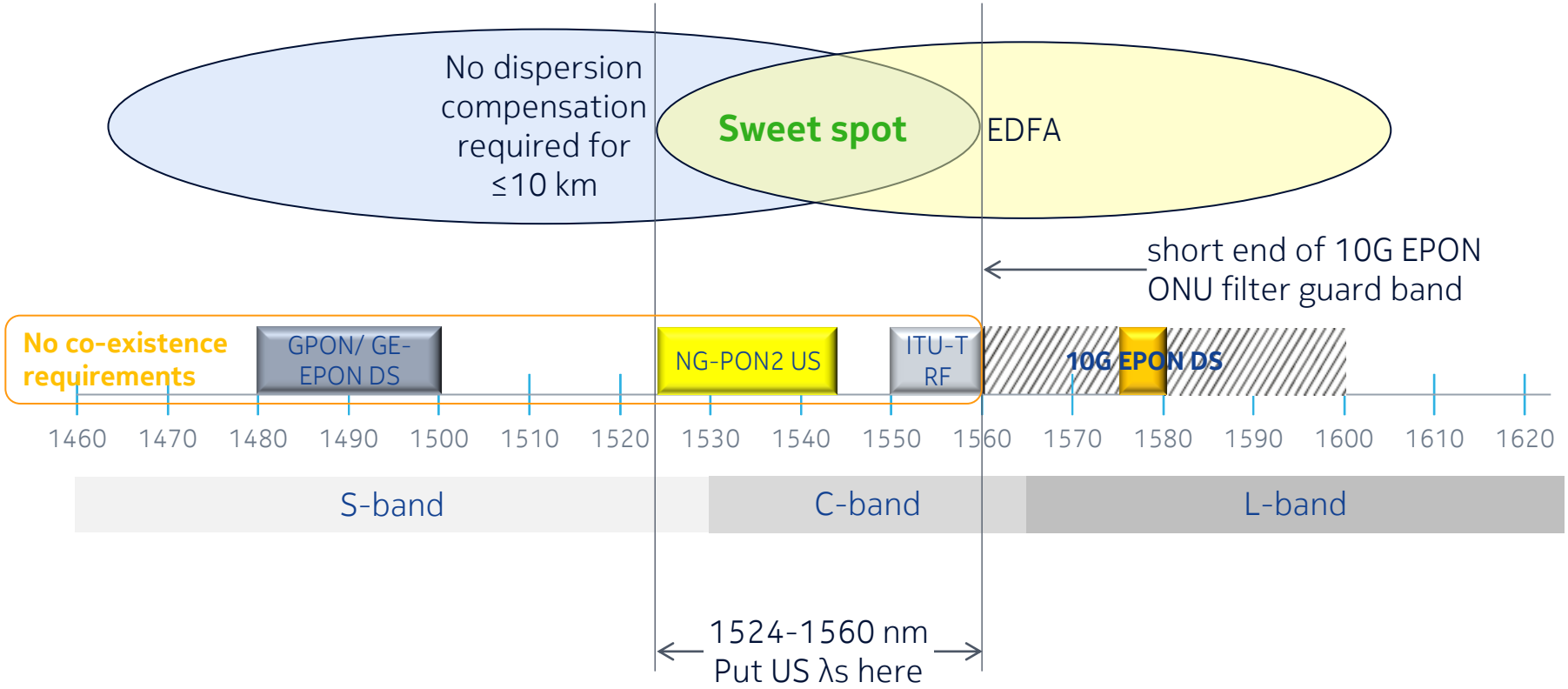
Cost-optimized 100G EPON will require an optical pre-amp in the OLT
to avoid optical post-amps in the ONU



- EDFAs have lower noise figure than SOAs.
- An EDFA preamp *might* be required to avoid post-amps in 100G ONUs, for PR30
  - There are EDFAs that support burst mode
- The need for EDFA might be even stronger for PR40
- EDFA is not an option if 100G wavelengths are in the O-band (Plans A, B, D, E)

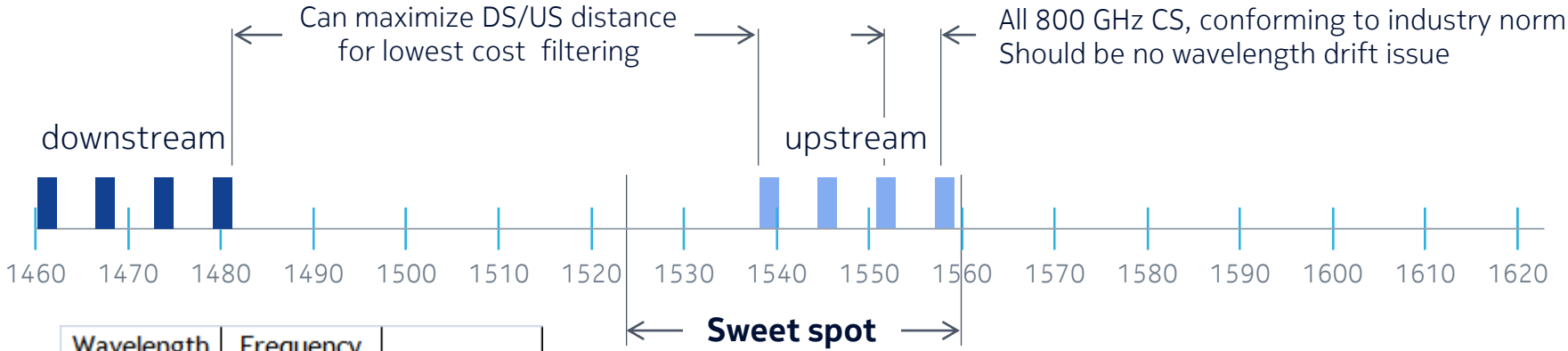
NOKIA

Choosing wavelengths for λ_1 - λ_4



NOKIA

Wavelength plan for λ_1 - λ_4. Assume 800 GHz CS



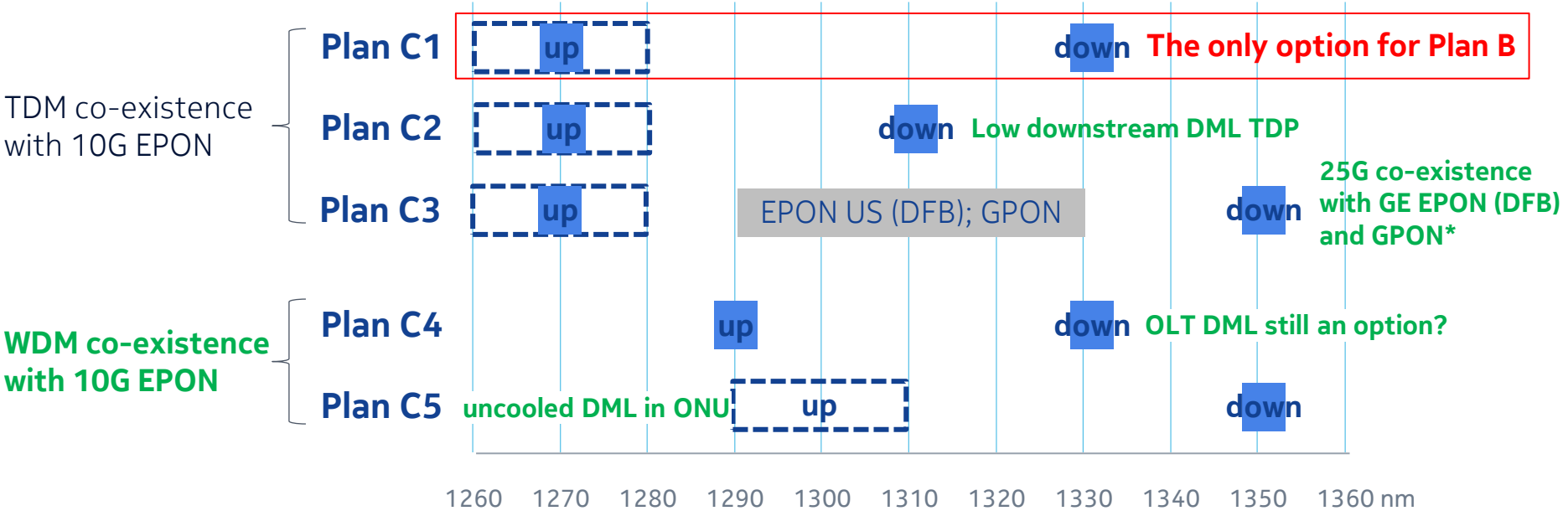
Wavelength (nm)	Frequency (THz)	Plan
1461.69	205.1	US 1
1467.41	204.3	US 2
1473.18	203.5	US 3
1479.00	202.7	US 4
1538.98	194.8	DS 1
1545.32	194	DS 2
1551.72	193.2	DS 3
1558.17	192.4	DS 4

Pure 100G EPON deployments can take advantage of lower fiber loss at these wavelengths

NOKIA

Choosing wavelengths for λ_0

Plan C allows for increased flexibility to optimize 25G EPON
- Cost-optimization
- TDM or WDM co-existence with 10G EPON
- Co-existence with gen 1 PONs



*may support CTC objective: "Promote IEEE and ITU-T coordination" including "Shared Unified wavelength plan" zhang_3ca_1b_0716.pdf

NOKIA

Dispersion compensation

Dispersion compensation fiber (DCF) for PONs > 10 km

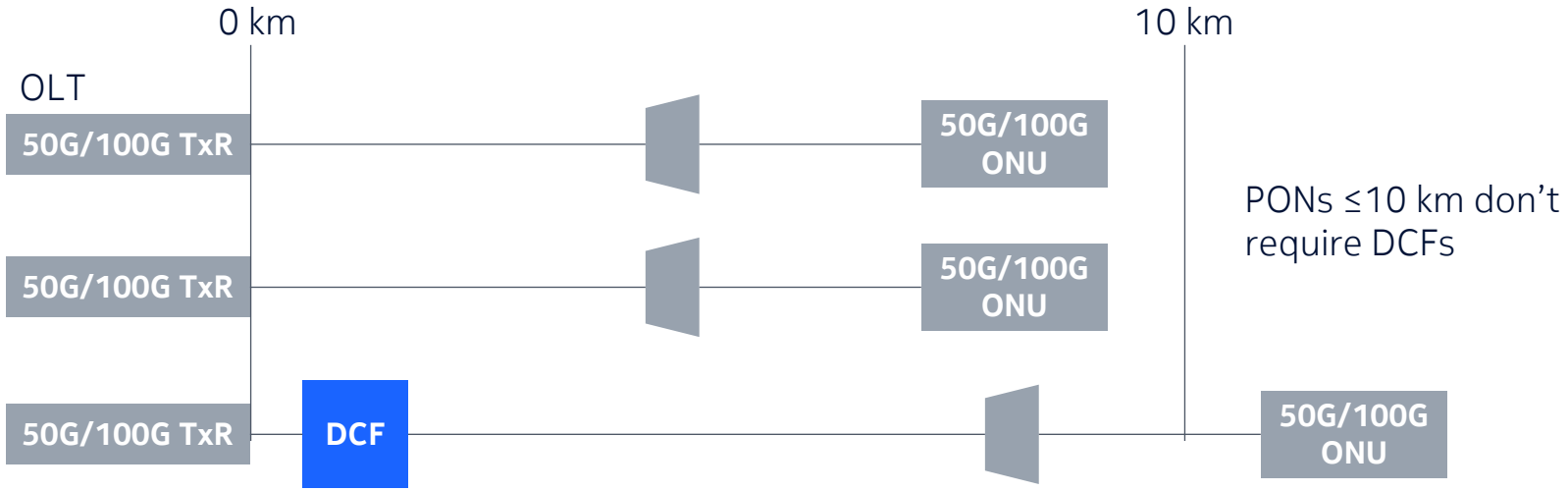
If >10 km PONs must be supported, DCF can be deployed in 1+4 (not in 1+3 if DS/US λ_0 is in the O-band)

Should be able to support any differential distance.

Characteristics

- Optical loss: e.g. spec: 1.2 dB (10 km)
- Size: e.g. module 9.2”x9.6”x0.75”
- Cost: low, relative to the cost of the 100G OLT transceiver

DCF deployment



- A DCF is installed at the OLT only for PONs >10 km
- The cost and space impact of DCFs is proportional to the % of PONs of >10 km reach. For most (all?) operators this will be small.
- **Or, just create a 10 km spec and make the issue go away (e.g.** miguelez_3ca_1a_0516.pdf**)**

NOKIA

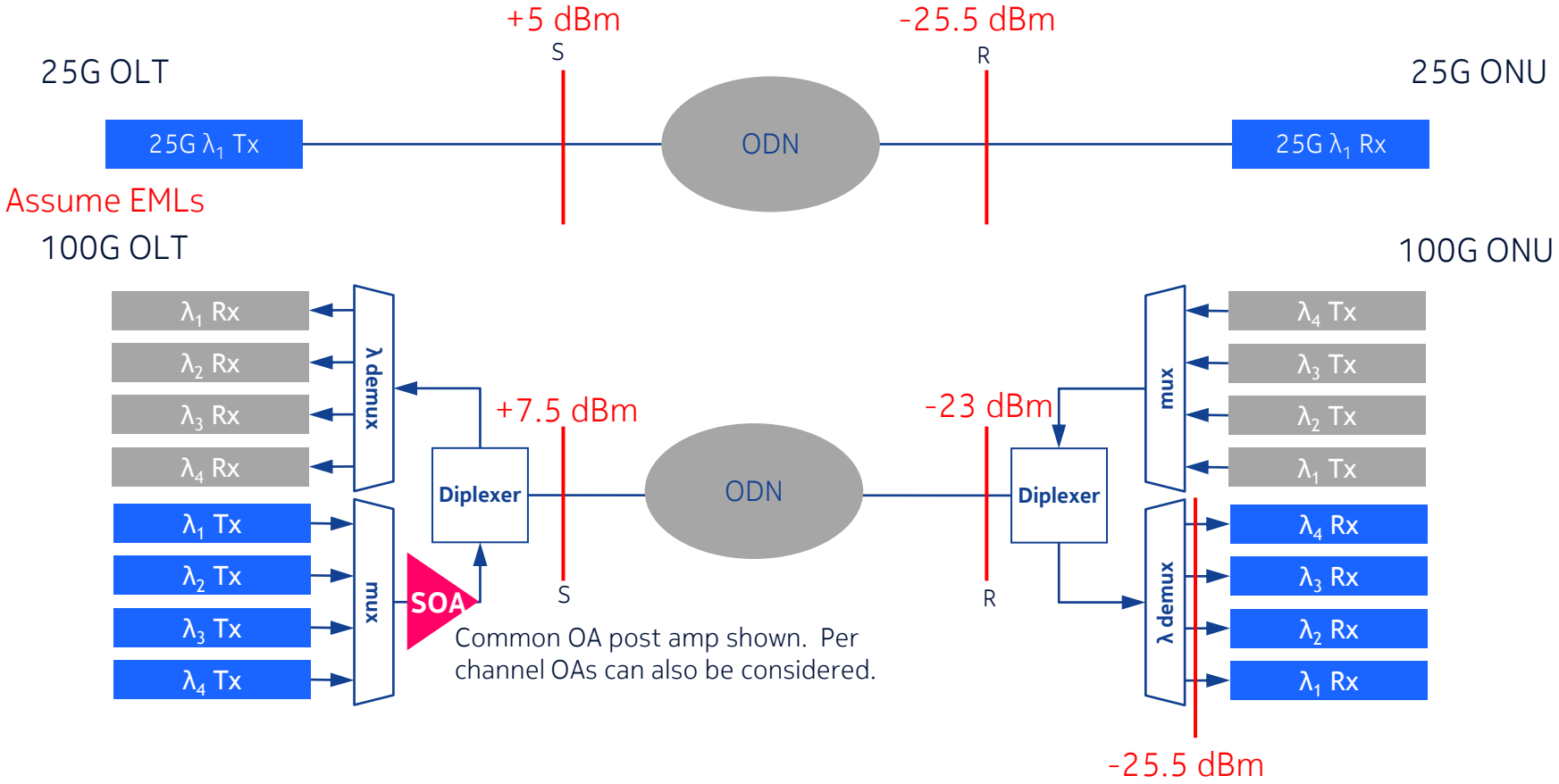
Power budget

Optical assumptions

- 100G mux and demux nominally add ~2.5 dB insertion loss each.
- Cost-optimized 100G EPON puts all optical amplification in the OLT
- Downstream TDP = 1.5 dB, upstream TDP = 3 dB (same as 10G EPON, but to be confirmed)
- PR30 loss budget
- There will be 1 dB FEC coding improvement in downstream relative to 10G EPON (to be confirmed)
- 1 dB improvement in PR30 APD receiver performance vs. 10G EPON + 5 dB penalty for 25G (per NeoPhotonics yield analysis, in harstead_3ca_1a_0516.pdf.)
- Launch power values from harstead_3ca_2a_0716.pdf

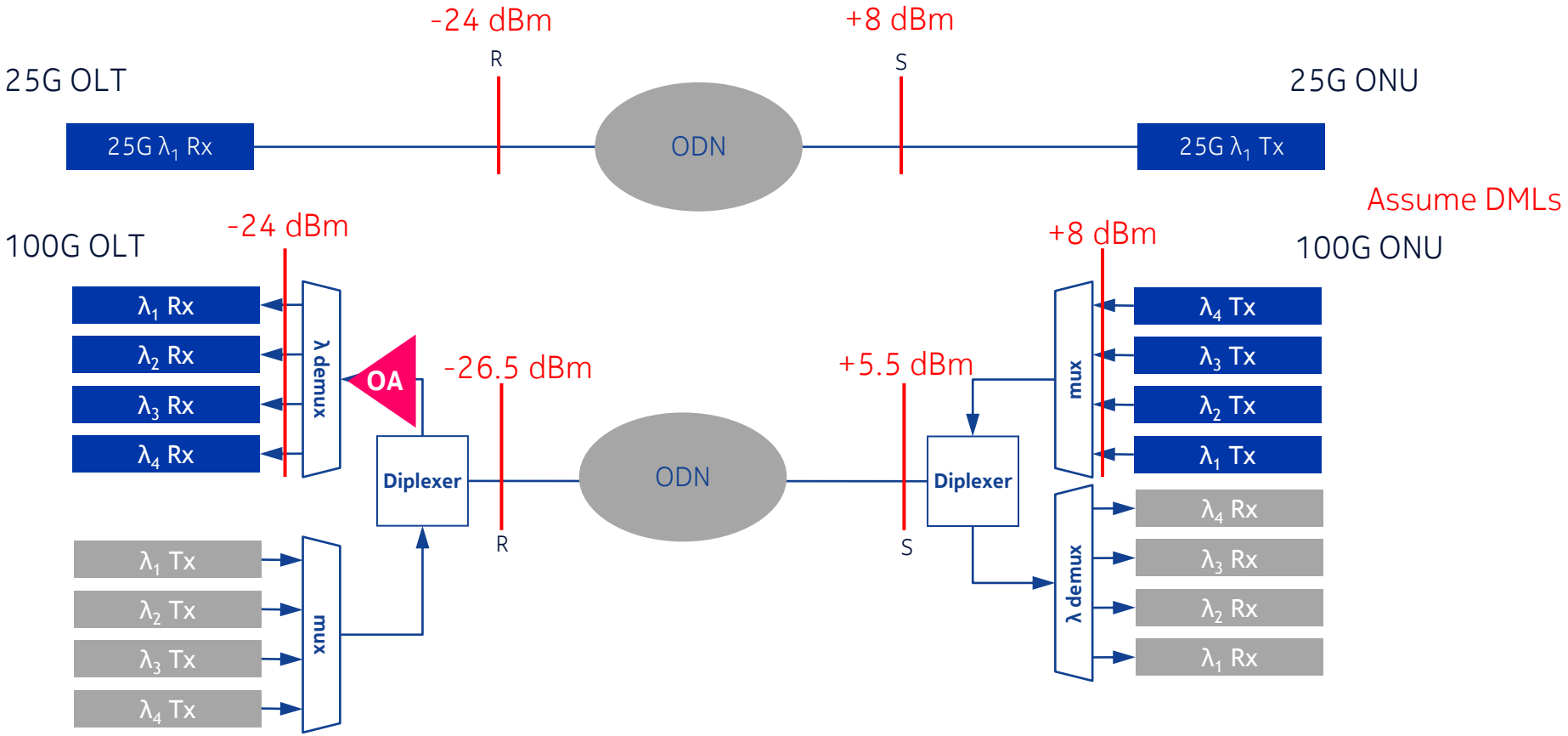
	AVP_{min} (dBm)	ER (dB)
EML	5	8
cooled DML	8	6

Downstream optical levels (per harstead_3ca_1_0916).



NOKIA

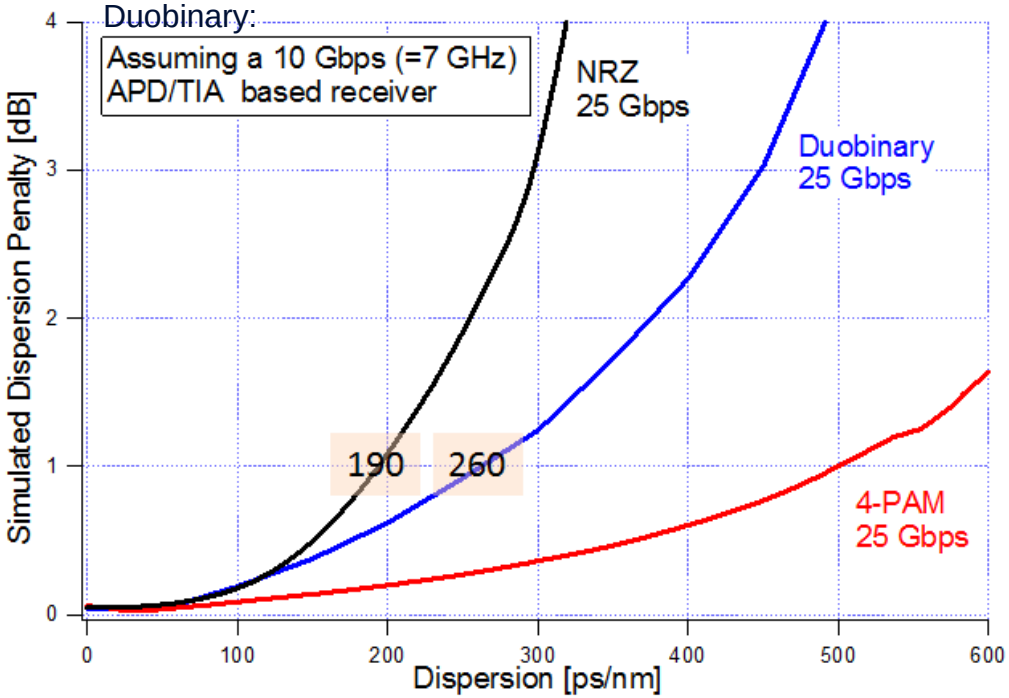
Upstream optical levels (per harstead_3ca_1_0916).



NOKIA


NOKIA

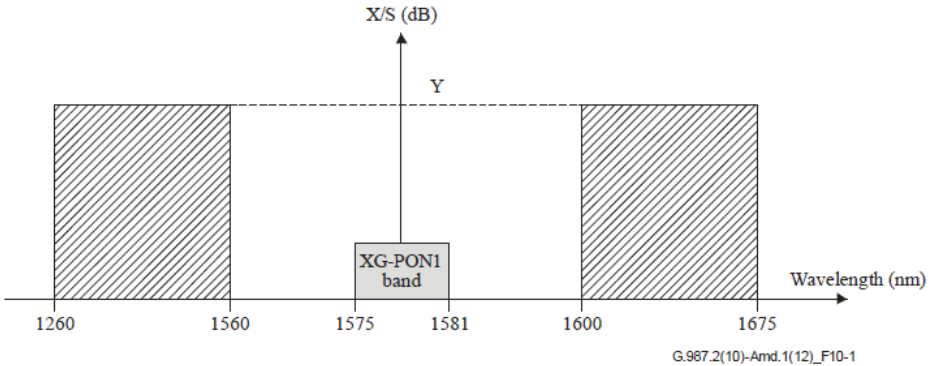
25 Gb/s dispersion tolerance (simulated)



Noise contributions, laser linewidth and non-linearities were not taken into account in the simulation.

NOKIA

10G PON ONU blocking filter

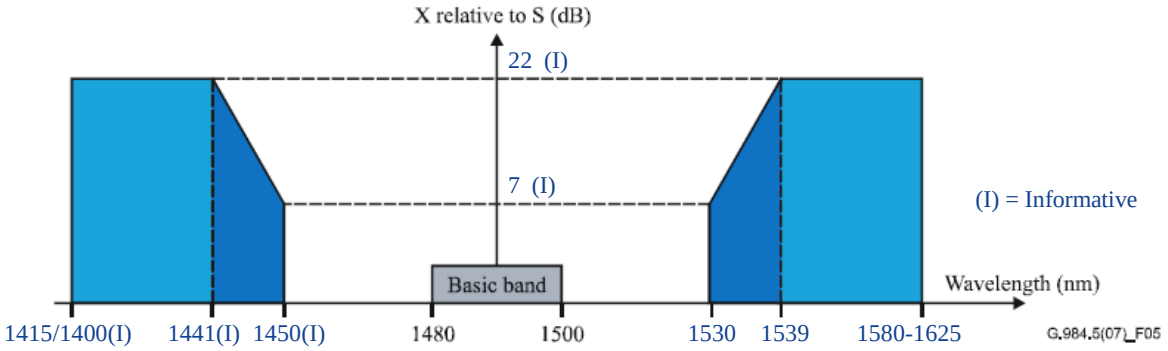


Class	Y (dB)
N1, E1, N2a, E2a	21.5
N2b, E2b	15

S: Received power of basic band.
X: Maximum total power of additional services received in the blocking wavelength range.
X/S: In the mask (hatching area) should not cause the XG-PON receiver to fail to meet its sensitivity requirements.

If GE-EPON and GPON co-existence were required for 100G EPON

ONU tolerance to interferers would constrain NG-EPON downstream wavelengths to ≥ 1539 nm.



S	Received power of basic band.
X	Maximum total power of NGA and video received in the blocking wavelength range.
X/S	in the mask (hatching area) should not cause the sensitivity of the basic band receiver to fail to meet the specified limit.
NOTE – λ3 value of 1400 *(Informative)* may be applicable for low-water-peak fibre only.	

NOKIA